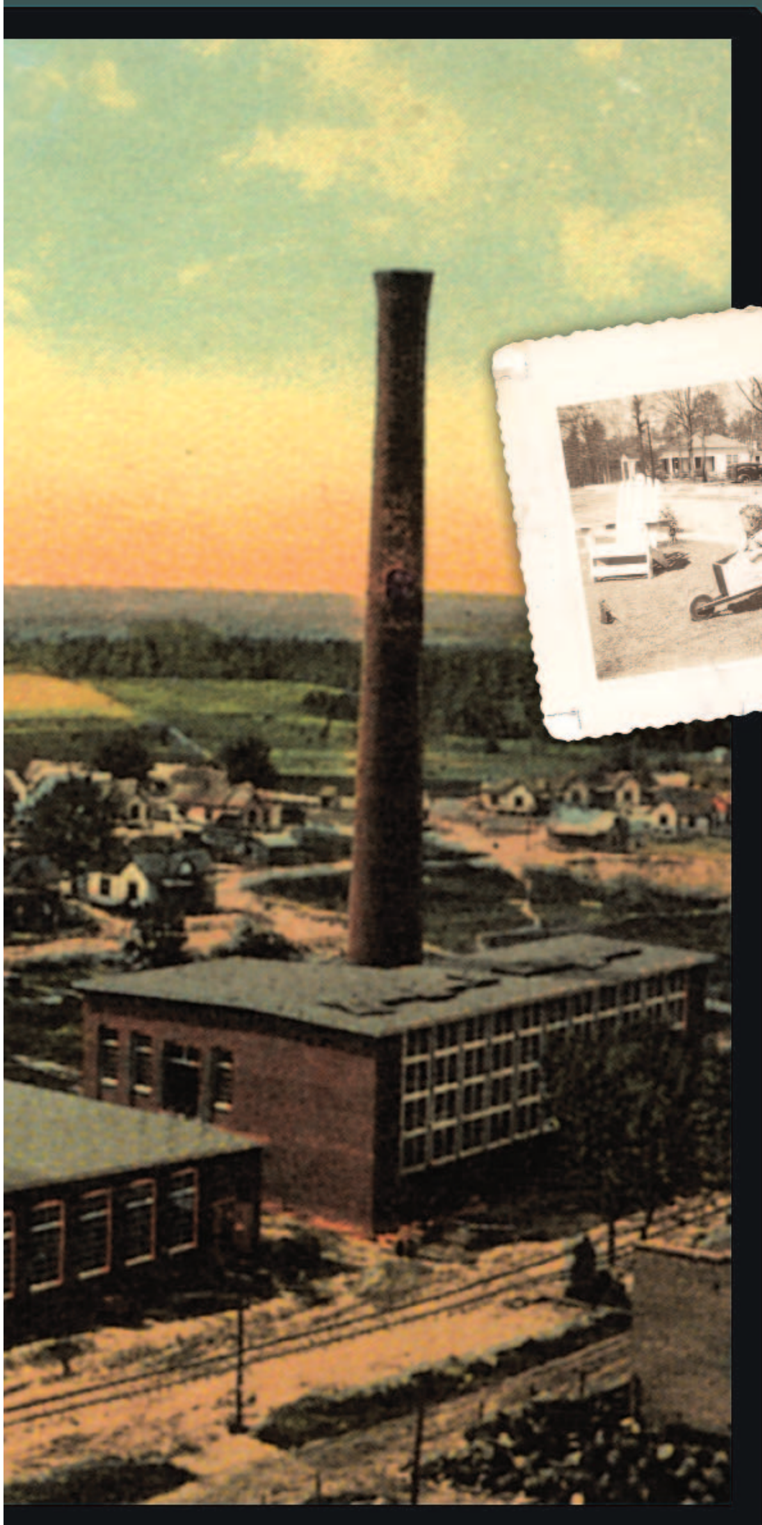
The Risk Where



Courtesy of John Schelp; inset: courtesy of Vivian Umberger

You Live

The U.S. Environmental Protection Agency (EPA) is perfecting a software model that ranks chronic human health risks from industrial pollution exposures for populations living anywhere in the United States. Produced by the EPA's Office of Pollution Prevention and Toxics (OPPT), the Risk-Screening Environmental Indicators (RSEI) model allows researchers to prioritize risk-reduction efforts by chemical, industry sector, and facility according to numerous geographic classifications such as states, counties, zip codes, and tribal areas.

RSEI splits the United States into a grid of 10 million cells, each a square kilometer in size. By linking industrial release data from the Toxics Release Inventory (TRI) to environmental fate models and estimates of human exposure, health threats within and between cells can be ranked and compared by the model. Similar assessments may have once taken months to complete, but RSEI yields answers to targeted queries in a matter of minutes.

With the model, users can sort chemical release and exposure data in nearly limitless ways, says Steven Hassur, a senior chemist in the OPPT's Economics Exposure and Technology Division, who is among the model's chief architects. Impacts can be compared among varying locations, among sex and age groups, and among facilities. "If you wanted to, you could focus in so narrowly as to say 'I'm interested in who's being affected by fugitive air releases of benzene from a particular refinery,'" Hassur says. "It's a question of framing your research goals and then selecting the questions you need to ask."

"RSEI is a very powerful tool," says George Lucier, an advisor to the National Toxicology Program, who has reviewed the model. "It allows you to quickly determine who's being affected by industrial facilities." Following completion of EPA review later this year, a new, updated edition of

RSEI—Version 2.1—will be released. Initially available only to EPA scientists, the updated version of RSEI will eventually be available to the public, as are current versions.

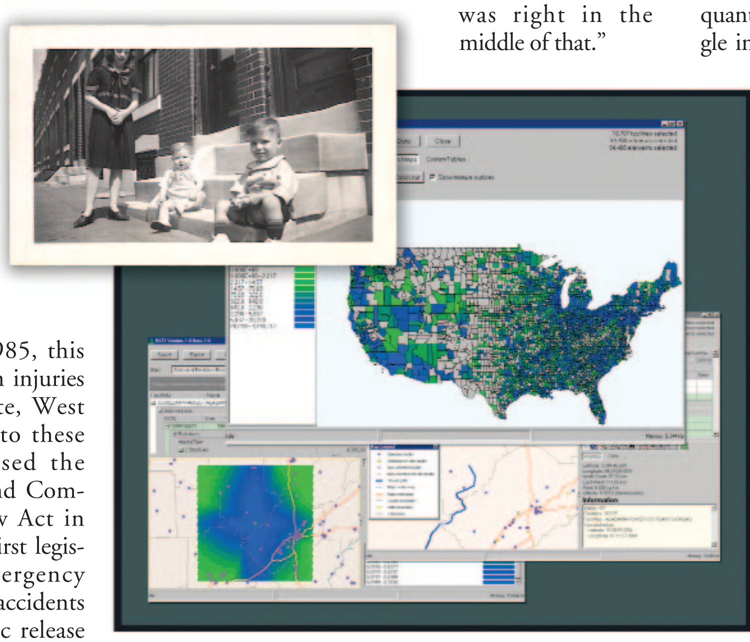
An Evolving History

RSEI is based in the EPA's community right-to-know initiatives, which were launched after a pair of infamous industrial accidents. During the first accident, in 1984, air releases of methyl isocyanate, used in the production of pesticides, leaked from a Union Carbide chemical plant in Bhopal, India. The release killed up to 10,000 people, injured many more, and caused ongoing health effects. Another Union Carbide plant inadvertently released the pesticide aldicarb in 1985, this time causing 135 known injuries in the town of Institute, West Virginia. Responding to these events, Congress passed the Emergency Planning and Community Right-to-Know Act in 1986. The act was the first legislation to promote emergency planning for industrial accidents and stipulated that toxic release data from all U.S. companies be made public.

Section 313 of the act created the TRI: companies report their permitted annual pollutant releases—and their accidental releases—to the EPA, which makes the information available on its TRI website. But although the TRI does identify potential hazards, it is also bogged down by an important limitation: Chemical releases are reported in pounds per year, with no further information about each chemical's toxicity or the magnitude of local exposures. And without this contextual information, officials have difficulty distinguishing the health risk posed by one facility versus another.

"It's misleading to say risk is merely a function of the mass of chemicals released," explains economist Nicolaas Bouwes, another architect of the model, who now works in the EPA's Office of Water. "It's imperative that chemical fate, transport, and toxicity information, in addition to the size of the exposed populations, are also considered. The extent of health risks are conditional on all these things."

The RSEI model was created by the EPA to put TRI data into a risk-based context. Version 1.0 was released in 1999 after eight years of stakeholder negotiations. "This was an incredibly politicized task for the EPA to take on," recalls Bill Pease, formerly director of Internet projects with Environmental Defense and now chief technology officer with Get-Active Software, a Berkeley, California–based company that provides web services to nonprofit organizations (including Environmental Defense). "We saw a long struggle over how to best integrate health effects and toxicity information with the raw TRI data. The EPA was right in the middle of that."



U.S. EPA; inset: courtesy of Thomas J. Goehl

But for the most part, the RSEI model succeeded, says Charles Pittinger, a principal scientist with The Cadmus Group, an environmental consulting firm in Boston, Massachusetts. "I take my hat off to Bouwes and Hassur for producing a robust model that incorporates consideration of chemical effects and exposure in a risk-based manner," he says.

A Combination of Combinations

RSEI's output falls into three general categories. The first ranks model results according to pounds of chemicals that individual facilities release annually. These results can be applied to any number of queries. For instance, one might seek to identify the state with the greatest volume of chemical releases, or the amounts of benzene released annually by all the petrochemical refineries in the United States. The second category ranks results by chemical hazards, which are derived by multiplying release volumes by corresponding toxicity weights. These values, which rank chemicals in terms of their relative potency, are created especially for the model by the OPPT and are distinct from those used in traditional risk assessment. The third and most comprehensive category is a risk ranking. In this case, hazard values are linked to fate, transport, and exposure models that generate a surrogate dose to actual populations as they are defined by the U.S. Census Bureau.

But although RSEI provides a risk context for industrial emissions, it is not risk assessment, from which it differs significantly. Risk assessments, which are much more time-consuming and expensive to perform, quantify effects of chemical exposure to single individuals or populations. A risk assessment might find that a carcinogen in drinking water is associated with a 10-fold elevation in cancer risk, for example. RSEI, on the other hand, is a strictly comparative process. "RSEI results are only meaningful when compared to each other," Bouwes explains.

Furthermore, unlike the case with risk assessment, RSEI toxicity weights don't separately address cancer and noncancer effects in examining chronic human health end points. The weights are based on the single most sensitive end point for the inhalational or oral exposure pathway (earlier versions considered the inhalational pathway only). Carcinogens and noncarcinogens can be examined separately, but they are linked by an equivalency in the toxicity weights, which allows them to be scored together. The most toxic chemicals—for example, asbestos and acrolein—have RSEI toxicity weights that are up to nine orders of magnitude higher than those associated with chemicals that have much lower chronic toxicity to humans, such as freon 113.

According to Hassur, the weights are based upon the toxicity information used to generate existing toxicity values, such as reference doses and cancer slope factors, which OPPT researchers obtain from a number of sources. Among them are the EPA's Integrated Risk Information System, the California Environmental Protection Agency, and the Agency for Toxic Substances and Disease Registry. Some high-priority chemicals (so designated in terms of their exposure volume or toxicity) lacked published toxicity values. In these cases, OPPT researchers calculated toxicity weights for the model if existing toxicological data in the scientific literature were sufficient to do so. "The goal is to put TRI chemicals in a meaningful order regarding chronic human health hazard," Hassur says.

A number of stakeholders have criticized the model's divergence from true risk assessment. Pease says RSEI's toxicity weights are "less than what the public wants," because they only allow for relative rankings that do not address critical questions such as whether the releases increase cancer risk or whether they result in risk levels that exceed statutory standards. "I don't think the model goes far enough," he says. "They could have generated conventional risk estimates like Scorecard.org [referring to Environmental Defense's online environmental information service, which publishes risk estimates for local communities by zip codes]. But this is probably as good as they are going to get," Pease concedes. "EPA would face a storm of stakeholder objections if it provided the public with screening-level risk assessments for all industrial facilities."

Applications for Pollution Prevention and Environmental Justice

Since the release of Version 1.0 in 1999, RSEI has become a valuable tool for federal and regional EPA scientists alike. Ezequiel Velez, TRI coordinator for EPA Region 4, has used the model to identify priorities for pollution prevention and control. "We also use it to supplement enforcement," he adds. "But our use of the model isn't regulatory; it's strictly a voluntary tool that allows companies to determine which chemicals pose the greatest hazards so they can adjust their compliance schedules accordingly."

Both Velez and Nora Lopez, his TRI counterpart in EPA Region 2, stress the importance of noting caveats in model results. The model incorporates many conservative assumptions that can make risks appear larger than they really are, Lopez says. For example, toxicity weights for metals and metal compounds intentionally assume the most toxic chemical species, an approach that Hassur justifies in light of inherent uncertainties in TRI data. TRI reporting does not indicate whether releases of chromium consist of hexavalent or trivalent chromium, for example. Therefore, the RSEI toxicity weight defaults automatically to the hexavalent species, which is vastly more toxic than the trivalent form often used by industry. "Sometimes, especially when facilities really look bad [in RSEI calculations], we have to go out and verify the data they report is correct," Lopez says. "Chromium tends to come up as a major issue."

But Velez points out that he's comfortable with the model's conservative approach, in part because nonindustrial sources of exposure are not considered. "The model doesn't incorporate risks from mobile sources like air emissions from cars," he says. "So, I have no problem with the higher industrial values. This is a screening tool that points toward areas for further study."

RSEI has also been a valuable tool for environmental justice studies that define risks based on sex, race, or socioeconomic status. The Political Economy Research Institute at the University of Massachusetts Amherst published a 2001 study based on the doctoral thesis of Marc Shapiro, then a graduate student at the University of Rochester, who collaborated with Bouwes and Hassur to use a database created by RSEI in analyzing disparate impacts of air pollutants by race, ethnicity, income, education level, and employment. The goal was to identify opportunities for risk reduction among communities throughout the United States. Their results confirmed what researchers had long suspected: human health risks from industrial pollution are comparatively higher among blacks and Asians compared to whites, and among Hispanics compared to non-Hispanics.

Changes in the way the U.S. Census Bureau defines population subgroups has made it more complicated for researchers to examine trends in environmental justice studies. This is because the question on race for the 2000 census was different from the one for the 1990 census in several ways. Most significantly, respondents were given the option of selecting one or more race categories to indicate their racial identity. Other changes included the composition and number of racial categories. Hassur admits that OPPT researchers haven't yet decided how the model will address the new population categories when examining changes over time. "We're waiting for the [census] experts to sort this out, and then we'll adopt whatever convention is developed," he says. In the meantime, he says, Version 2.1 capabilities available to the public in this regard are limited to age and sex.

Moving Forward

In the latest incarnation of the model, a number of key improvements enhance functionality. For instance, RSEI has until now considered only inhalational exposures, whereas Version 2.1 adds surface water ingestion and the consumption of locally caught fish to the mix of exposure pathways. Despite the new model's capacity to consider multiple exposure pathways, Velez concedes that only the inhalational pathway is now tapped by Region 4 investigators. "We've found that although sixty-five to eighty percent of industrial releases are to air, the [inhalational] pathway accounts for more than ninety percent of the risk," he explains.

In other improvements, Version 2.1 includes the most recent TRI reporting data (all years from 1988 to 2000) and census data (for 1990 and 2000). "It also has much more robust mapping and improved facility locations," says Richard Engler, a chemist in the Industrial Chemistry Branch of the OPPT. "And the fate and transport modeling is much more sophisticated."

At this point, the model's release is expected by the end of the 2003 fiscal year, which ends in September. Fortunately, the model has dodged what some saw as a critical pitfall that might have derailed it altogether: national security concerns over the public availability of risk information for specific facilities. According to Hassur, RSEI passed its EPA review for national security purposes mainly because RSEI models only chronic exposures, in which daily release rates are obtained by averaging the TRI's annual reporting data over an entire year. In a terrorist attack, acute exposures from sudden large-scale releases would be the major concern.

Once RSEI is released, it will be updated annually for consistency with current TRI and toxicity data. But the model's computational functioning is essentially completed, Hassur says. "We want to get the model on the web, but that's a more long-term goal. By moving onto the web we could do updates on a more routine basis. But we're not expecting much more by way of model changes for the CD-ROM version."

Charles W. Schmidt

Suggested Reading

Bouwes NW, Hassur SM, Shapiro MD. 2001. Empowerment Through Risk-Related Information: EPA's Risk Screening Environmental Indicators Project. Working Paper WP18. Amherst, MA:University of Massachusetts Amherst, Political Economy Research Institute.

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